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PROJECTIONS OF DEMAND FOR WATERBORNE TRANSPORTATION, OHIO RIVER—ETC(U)
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Executive Summary

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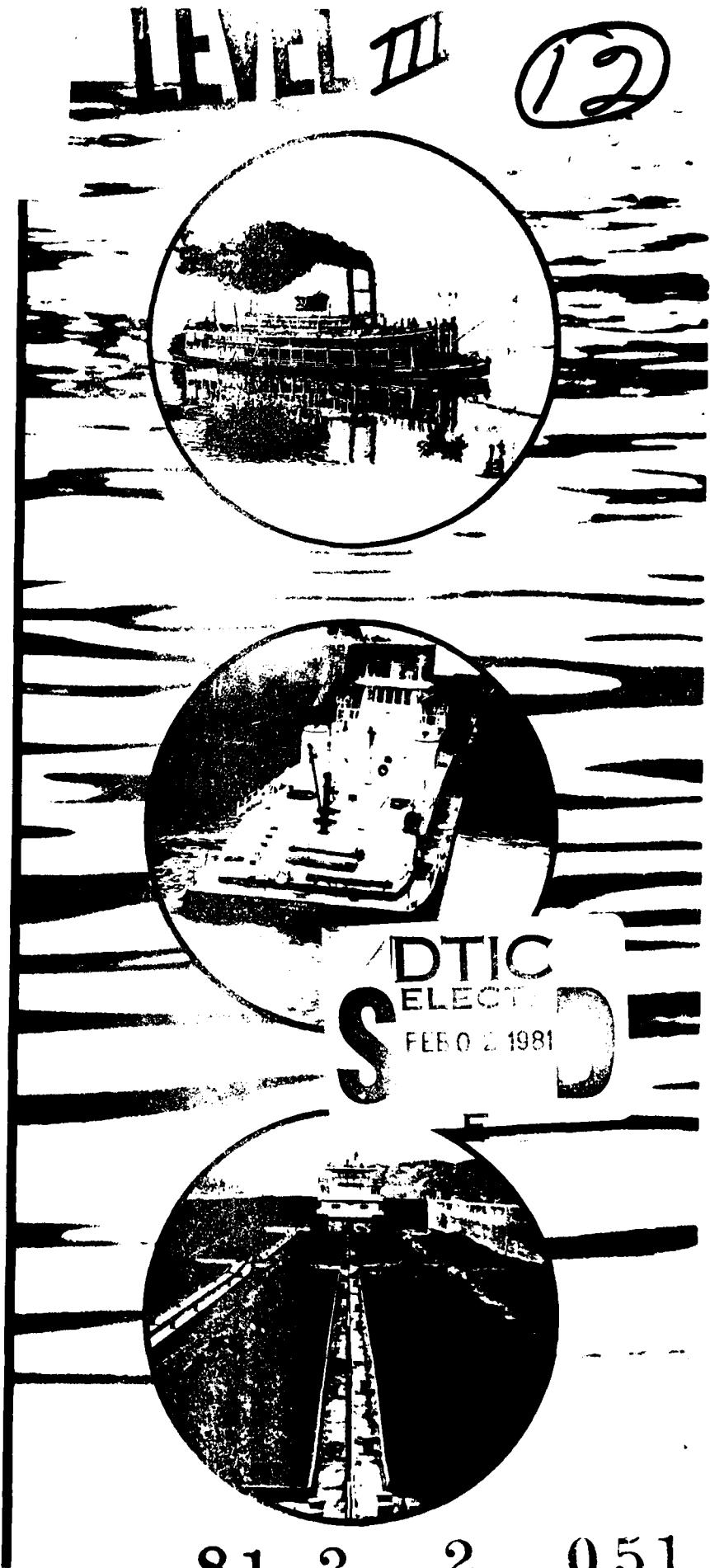
Projections Of Demand
For Waterborne
Transportation

Ohio River Basin
1980 - 2040

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Cincinnati, Ohio

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This Corps of Engineers report describes one of three independent but complementary studies of future freight traffic on the Ohio River Basin Navigation System. Each of the studies considers existing waterborne commerce and develops a consistent set of projections of future traffic demands for all of the navigable waterways of the Basin. Each report contains information on past and present waterborne commerce in the Basin and projections by commodity group and origin-destination areas from 1976 to at least 1990.		

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(Continued from #20)

The three study projections, in conjunction with other analytical tools and system information, will be used to evaluate specific waterway improvements to meet short and long-term navigation needs. The output from these studies will serve as input to Corps' Inland Navigation Simulation Models to help analyze the performance and opportunities for improvement of the Ohio River Basin Navigation System. These data will be used in current studies relating to improvement of Gallipolis Locks, the Monongahela River, the Upper Ohio River, the Kanawha River, the Lower Ohio River, the Cumberland River and the Tennessee River, as well as other improvements.

This document is the Executive Summary of the Study.

The study included a Commodity Resource Inventory, a Modal Split Analysis and a Market Demand Analysis. The work included investigation and analyses of the production, transportation and demand characteristics of each of the major commodities transported on the Ohio River and its tributaries. For each of 15 commodity groups, the demand for waterway transportation into, out of and within the Ohio River Basin was projected through the year 2040. A detailed study analysis and discussion for each commodity group is presented in 15 individually bound reports, supplemented by a methodology report. A study summary aggregates the commodity group totals for each of the several projection periods and lists the total waterborne commerce for each of the 72 operational locks and dams in the Ohio River Basin. The study results are presented in the following 17 documents:

<u>Volume</u>	<u>Subject Title</u>
1	Study summary
2	Methodology
3	Group I: Coal and coke
4	Group II: Petroleum fuels
5	Group III: Crude Petrol.
6	Group IV: Aggregates
7	Group V: Grains
8	Group VI: Chemicals and chemical fertilizers
9	Group VII: Ores and Minerals
10	Group VIII: Iron ore, steel and iron
11	Group IX: Feed and food products, nec.
12	Group X: Wood and paper products
13	Group XI: Petroleum products, nec.
14	Group XII: Rubber, plastics, nonmetallic, mineral, products, nec.
15	Group XIII: Nonferrous, metals and alloys, nec.
16	Group XIV: Manufactured products, nec.
17	Group XV: Other, nec.

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EXECUTIVE SUMMARY

PROJECTIONS OF DEMAND FOR WATERBORNE TRANSPORTATION, OHIO RIVER BASIN, 1980, 1990, 2000, 2020, 2040.

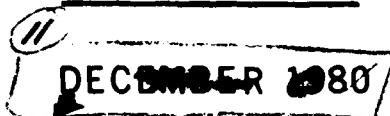
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U.S. ARMY CORPS OF ENGINEERS
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Contract No. 15 DACW69-78-C-0136

by

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PREFACE

This Corps of Engineers report describes one of three independent but complementary studies of future freight traffic on the Ohio River basin navigation system. Each of the studies considers existing waterborne commerce and develops a consistent set of projections of future traffic demands for all of the navigable waterways of the basin. Each report contains information on past and present waterborne commerce in the basin with projections by commodity group and origin-destination areas from 1976 to either 1990 or 2040.

The three projections, in conjunction with other analytical tools and waterway system information, will be used to evaluate specific waterway improvements required to meet short and long-term navigation needs. The output from these studies will serve as input to Corps inland navigation simulation models to help analyze the performance and requirements for improvements of the Ohio River basin navigation system. These data will be used in current studies relating to improvements of Gallipolis Locks, the Monongahela River, the Upper Ohio River, the Kanawha River, the Lower Ohio River, and the Tennessee River, as well as for other improvements.

The reports on the three studies are referred to as the "CONSAD," the "BATTELLE," and the "NATHAN" reports. The latter and final report was completed in November 1980. It was prepared for the Corps of Engineers by Robert R. Nathan Associates, Inc., Consulting Economists, Washington D.C. This study encompasses the period 1976-2040, and is by far the most detailed of the three.

The "CONSAD" report, completed in January 1979, was prepared for the Corps by the CONSAD Research Corporation of Pittsburgh, Pennsylvania. The study and the 1976-1990 projected traffic demands discussed in that report were developed by correlating the historic waterborne commodity flows on the Ohio River navigation system, with various indicators of regional and national demands for the commodities. The demand variables which appeared to best describe the historic traffic pattern for each of the commodity groups was selected for projection purposes. The projected values for the demand variables are based upon the 1972 OBERS Series E Projections of National and Regional Economic Activity. The OBERS projections serve as national standards and were developed by the Bureau of Economic Analysis of the U.S. Department of Commerce, in conjunction with the Economic Research Service of the Department of Agriculture.

The "BATTELLE" report was completed in June 1979, and was prepared for the Corps by the Battelle Columbus Laboratories, Columbus, Ohio. The study and the 1976-1990 traffic projections discussed in that report were developed by surveying all waterway users in the Ohio River Basin through a combined mail survey and personal interview approach. The purpose of the survey was to obtain an estimate from each individual shipper of his future commodity

movements, by specific origins and destinations, as well as other associated traffic information. All identifiable waterway users were contacted and requested to provide the survey information. In addition, personal interviews were held with the major shippers. The responses were then aggregated to yield projected traffic demands for the Ohio River navigation system.

The "NATHAN" report presents the findings of a commodity resource inventory, a modal split analysis and a market demand analysis. The work included investigation and analyses of the production, transportation, and demand characteristics of each of the major commodities transported on the Ohio River and its tributaries. For each of 15 commodity groups, the demand for waterway transportation into, out of, and within the Ohio River basin was projected through the year 2040. A detailed study analysis and discussion for each commodity group is presented in 15 individually bound reports, supplemented by a methodology report. A Study Summary and an Executive Summary present appropriately abbreviated discussion and findings resulting from these analyses. The Study Summary aggregates the commodity group totals for each of the several projection periods and lists the total waterborne commerce for each of the 72 operational locks and dams in the Ohio River Basin.

The "NATHAN" report, "Projections of Demand for Waterborne Transportation, Ohio River Basin, 1980, 1990, 2000, 2020, 2040" consists of the following volumes:

<u>Subject Title</u>	<u>Number of Pages</u>	<u>Volume Number</u>
Study Summary	220	1
Methodology	118	2
Group I: Coal and Coke	134	3
Group II: Petroleum Fuels	66	4
Group III: Crude Petroleum	42	5
Group IV: Aggregates	64	6
Group V: Grains	131	7
Group VI: Chemicals and Chemical Fertilizers	90	8
Group VII: Ores and Minerals	61	9
Group VIII: Iron Ore, Steel and Iron	104	10
Group IX: Feed and Food Products, Nec.	44	11
Group X: Wood and Paper Products	61	12
Group XI: Petroleum Products, Nec.	38	13
Group XII: Rubber, Plastic, Nonmetallic Mineral Products, Nec.	41	14
Group XIII: Nonferrous Metals and Alloys, Nec.	57	15
Group XIV: Manufactured Products Nec.	35	16
Group XV: Others, Nec.	48	17

Additionally, an Executive Summary is available as a separate document.



**PROJECTIONS OF DEMAND FOR WATERBORNE
TRANSPORTATION
OHIO RIVER BASIN
1980, 1990, 2000, 2020, 2040**

Executive Summary

Prepared for
U.S. Army Corps of Engineers
Huntington District
Contract No. DACW69-78-C-0136

by
Robert R. Nathan Associates, Inc.
Consulting Economists
Washington, D.C.

November 1980

EXECUTIVE SUMMARY

This is a summary of the findings of the Commodity Resource Inventory, Modal Split Analysis and Market Demand Analysis of the Ohio River Basin (ORB) undertaken by Robert R. Nathan Associates, Inc. (RRNA) for the U.S. Army Corps of Engineers, Huntington District. The Corps of Engineers is responsible for constructing and maintaining the locks, dams, and channels that make the Ohio River System (ORS) navigable.

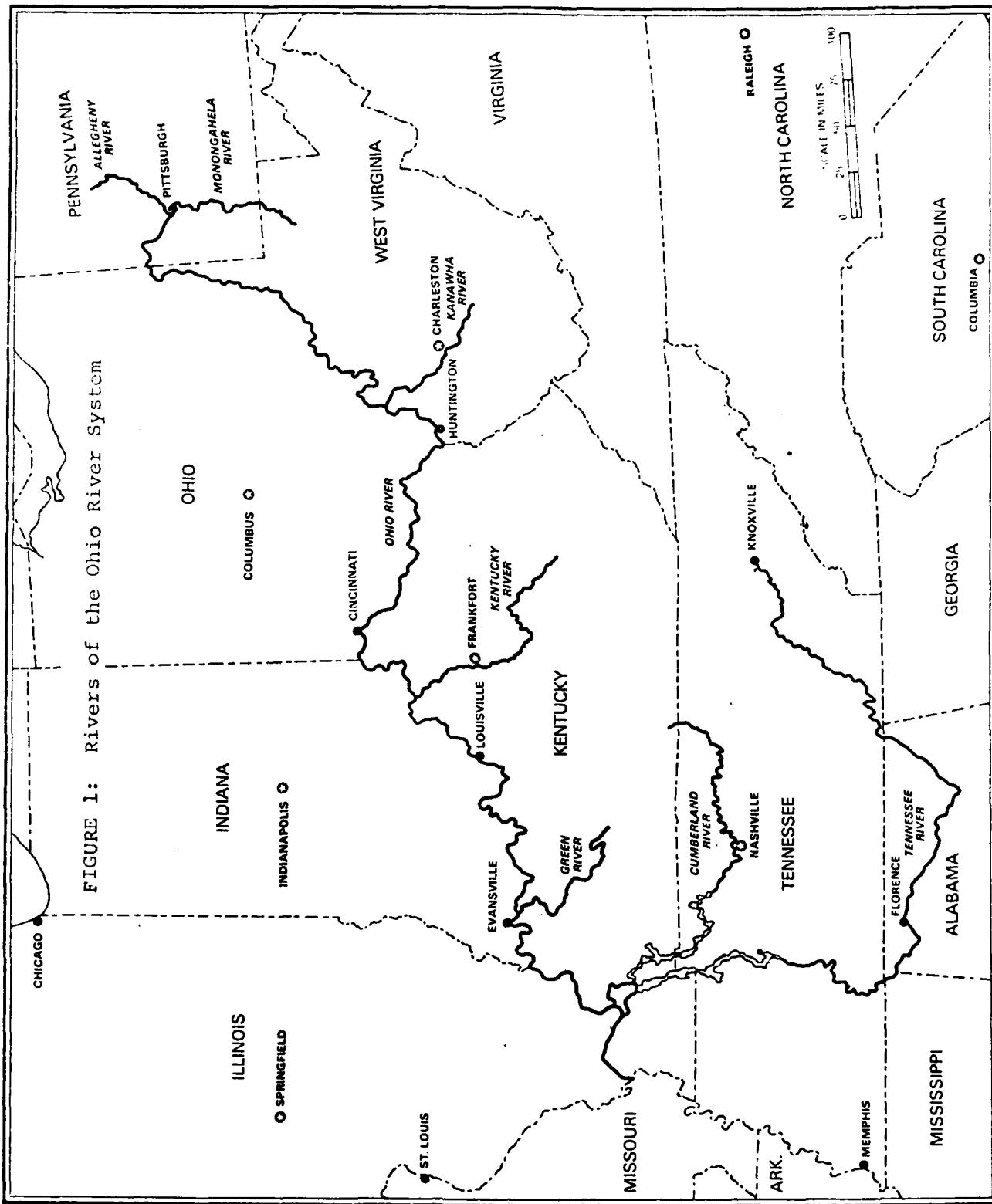
The Ohio River Basin (ORB) covers an area of 204,000 square miles in 14 states. It includes such economically diverse areas as the coal fields of Appalachia, the industrialized centers of Pittsburgh and Cincinnati, and the rich farmlands of Illinois and Indiana.

Access to water transportation has contributed significantly to the economic development of the region. The 2,600-mile Ohio River System (ORS) moves now more than 200 million tons of traffic into, from, and within the region annually.

A. Objective and Scope of the Study

The objective of this study was to project the demand for waterway commodity transportation on the ORS by origin and destination port equivalents (PEs) through the year 2040. This objective was reached through investigation and analysis of the production, transportation, and demand characteristics of each of the major commodity groups transported in the ORS. Figure 1 depicts the Ohio River and its navigable tributaries.

The projections of demand for waterway transportation will be used by the Corps of Engineers as an input to the water resource development activities for which the Corps has responsibility.



Fifteen commodity groups were the targets of the analysis:

<u>Group</u>	<u>Commodity/Product</u>
I	Coal and coke
II	Petroleum fuels
III	Crude petroleum
IV	Aggregates
V	Grains
VI	Chemicals and chemical fertilizers
VII	Ores and minerals
VIII	Iron ore, steel, and iron
IX	Food and feed products, not elsewhere classified (nec.)
X	Wood and paper products
XI	Petroleum products, nec.
XII	Rubber, plastic, and nonmetallic mineral products, nec.
XIII	Nonferrous metals and alloys, nec.
XIV	Manufactured products, nec.
XV	Others, nec.

For each of these groups, historical and projected production and consumption levels were determined by origin and destination points. The analysis focused on Bureau of Economic Analysis Areas (BEAs), a geographic classification of the Department of Commerce that subdivides the country into 173 study areas.

B. Overview of ORS Waterborne Traffic

Waterborne traffic in the ORS totaled 67 million tons in 1950.¹ Ten years later, in 1960, commerce in the ORS had reached 105 million tons, an average annual increase of 4.6 percent.² By 1969, waterborne traffic in the ORS equaled 161 million tons. During the years 1969-75, total ORS traffic was in a range of 160 to 175 million tons.

In 1976, waterway traffic in the ORS exceeded 200 million tons, an increase of 30 million tons over the preceding year. The substantial increase between 1975 and 1976 was the result of a 17

1. U.S. Army Corps of Engineers, Annual Report of the Chief of Engineers, 1951 ed. (Washington, D.C.: GPO, 1952), Vol. II.

2. U.S. Army Corps of Engineers, Waterborne Commerce of the United States, 1960 ed. (n.p.: COE, n.d.), Vol. II.

million ton increase in coal movements and a 7 million ton increase in aggregates traffic (which restored aggregates movements to earlier levels). Coal and coke have been, and will continue to be, the major commodities (in terms of tonnage) moving by water in the ORS. Between 1969 and 1976, 55 percent of ORS traffic was coal and coke.

Most waterborne traffic in the ORS is local (i.e., from one PE to another PE in the ORS). During the period 1969-76, however, outbound waterway shipments from the ORS increased at an average annual rate of 7.1 percent, from 16.6 million tons to 26.9 million tons. Most of this increase resulted from increases in the outbound shipments of coal, coke, and grains.

Inbound shipments to the ORS increased at an average annual rate of 5.2 percent during the period 1969-76, from 20.7 million tons to 29.4 million tons. Major increases were reported for coal and coke, petroleum fuels, and chemicals and chemical fertilizers.

C. Study Approach and Methods

The commodity demand study of the Ohio River System consisted of two major tasks: first, the identification and analysis of historical commodity flows; and second, projections of future commodity flows. Included in these tasks were the assessments of historical and future market demands and resource inventories for each of the 15 commodity groups. Analysis of historical modal splits and transportation trends was a major component in the projection of future transportation patterns.

The initial step was the identification of those areas within the Ohio River Basin designated as Primary Study Areas (PSAs) that have been ultimate origins or destinations of waterborne movements. These PSAs are aggregations of counties, either BEAs or BEA segments. PSAs were identified and confirmed through field interviews and an extensive telephone survey of shippers and receivers.

To determine historical production and consumption by PSA, estimates of county-level production and consumption were obtained either from published sources or were estimated. In many cases, county estimates were made by disaggregating existing national, regional, or state production/consumption estimates on the basis of such distribution factors as county employment, earnings, population, or production capacity. Many industry associations and individual commodity producers were contacted to verify these estimates.

Historical commodity movements were estimated on the basis of waterborne and rail shipment data provided by the Corps of Engineers. Truck shipments were derived from commodity production and consumption estimates and the waterborne and rail shipment statistics.

These estimates were analyzed to determine what factors affect modal choice, and to identify past trends and probable changes in trends relevant to these choices. Explicit consideration was given to the opinions and expert judgments of government agency staff members, shippers and receivers, and professional researchers associated with education and research institutions in the ORB. During the course of this investigation, over 200 field interviews and approximately 400 telephone interviews were conducted.

Future production and consumption of commodity groups by PSA were projected for the years 1980, 1990, 2000, 2020, and 2040. These projections are presented in Table 1 and usually were based on existing national and regional projections developed by Federal agencies. They were disaggregated to PSA levels and adjusted on the basis of field research. A major aim of the projection methodology was to develop a consistent set of projections for each commodity group. Thus, the U.S. Department of Energy was the source for all energy-related commodities; the Bureau of Mines was the source of non-energy, nonferrous mineral and ore projections; the U.S. Department of Agriculture was the source of grains projections, and some chemical fertilizer and food and feed production projections. Projections of economic activity by industry from the Bureau of Economic Analysis for OBERS Projections were used for the remaining commodities.

Projections of commodity shipments, receipts, and modal splits were based on projections of production and consumption, by PSA, on 1976 traffic patterns and on past trends. Adjustments were made to reflect the judgments of industry experts and the stated intentions of individual firms. The 1976 waterborne traffic movements were verified through an extensive survey performed for the Corps of Engineers. Waterborne commerce data for earlier years were less reliable, thereby requiring relatively heavy reliance on interviews with industrial shippers and receivers to identify past shifts in trends.

D. Study Findings

Through the year 2000, total ORS waterborne commerce is expected to have an average annual increase of 2.2 percent (Table 2).

Table 1. Ohio River Basin: Production, Consumption and Net Shipments by Commodity Group,
Estimated 1976 and Projected 1980-2040, Selected Years
(Thousands of tons unless otherwise specified)

Group	Estimated 1976	Projected			Average annual percentage change 1976-2000 2000-2040		
		1980	1990	2000	2040	1976-2000	2000-2040
Production:							
Group I: Coal and coke ^a	436,993.0	481,431.0	627,200.0	736,547.5	931,672.6	1,136,818.3	2.2
Group II: Petroleum fuels	15,841.7	18,162.3	24,509.0	22,916.0	17,530.7	10,202.9	1.6
Group III: Crude petroleum	2,153.8	2,097.6	2,041.9	1,846.7	1,232.9	554.9	(2.0) (0.6)
Group IV: Aggregates	127,935.4	135,611.3	156,594.4	172,248.3	204,570.7	222,546.3	1.3
Group V: Grains ^b	25,576.9	19,859.7	25,199.4	32,549.6	39,361.2	46,719.5	0.6
Group VI: Chemicals, fertilizers	9,892.0	11,964.9	16,394.5	24,068.3	43,398.8	58,506.7	0.9
Group VII: Ores and minerals ^c	82.5	88.8	119.3	178.6	296.1	490.9	2.3
Group VIII: Iron ore, steel	67,721.4	75,252.9	76,421.9	84,765.1	107,436.2	123,200.6	2.6
Group IX: Feed and food products	3,208.6	4,252.6	5,099.0	6,082.0	8,462.0	10,035.0	0.9
Group X: Wood and paper products ^d	5,788.3	6,922.7	9,049.7	11,407.6	16,796.1	20,808.0	1.3
Group XI: Petroleum products ^e	1,026.9	1,918.7	2,272.2	2,124.5	1,625.3	945.9	1.5
Group XII: Rubber, plastics ^f	4,215.0	6,047.0	8,562.0	10,520.0	12,428.0	13,545.0	2.0
Group XIII: Nonferrous metals ^g	2,771.2	3,610.4	6,692.4	9,309.1	18,407.2	25,236.1	0.6
Group XIV: Manufactured products ^h	7,449.0	9,905.0	14,252.3	20,061.1	35,621.5	47,984.3	2.4
Group XV: Others, nec. ⁱ	15,273.5	17,061.7	15,425.4	16,253.8	18,661.7	20,685.4	2.2
Total production	725,934.2	794,186.6	990,413.4	1,151,478.2	1,457,499.0	1,738,279.8	0.6
Consumption:							
Group I: Coal and coke ^a	194,578.4	216,792.8	268,856.5	334,826.2	465,257.4	606,624.0	1.5
Group II: Petroleum fuels	47,592.3	49,895.8	59,621.3	64,826.8	54,249.3	38,188.3	(1.3)
Group III: Crude petroleum	1,880.2	2,663.1	2,015.1	1,884.1	1,441.3	838.8	(2.0)
Group IV: Aggregates	132,319.2	139,680.5	161,785.4	178,855.8	211,521.6	229,685.8	0.6
Group V: Grains ^b	22,081.5	22,352.2	23,323.4	25,139.0	26,104.0	27,102.8	0.2
Group VI: Chemicals, fertilizers	15,262.2	16,140.5	22,250.3	30,725.2	52,344.8	69,231.6	3.0
Group VII: Ores and minerals ^c	6,720.2	8,289.3	13,503.2	18,987.9	33,076.4	45,664.3	2.2
Group VIII: Iron ore, steel	89,416.1	100,662.6	101,286.0	116,005.2	155,314.8	183,544.2	4.4
Group IX: Feed and food products	4,864.3	5,216.0	6,075.6	7,155.5	9,420.7	10,930.6	1.2
Group X: Wood and paper products ^d	13,247.5	15,811.4	22,971.2	29,984.7	45,873.4	58,779.1	1.1
Group XI: Petroleum products ^e	2,883.7	3,326.2	4,382.1	5,308.6	4,445.1	3,126.8	1.7
Group XII: Rubber, plastic ^f	7,313.9	11,429.7	16,677.5	19,942.2	25,044.2	28,511.3	2.6
Group XIII: Nonferrous metals ^g	1,464.9	1,814.0	2,681.2	3,575.9	6,050.3	7,893.2	0.9
Group XIV: Manufactured products ^h	6,546.8	7,393.1	10,419.7	14,653.7	26,469.2	35,925.7	2.3
Group XV: Others, nec. ⁱ	5,373.9	5,922.4	6,051.5	6,557.3	7,615.9	8,169.5	0.6
Total consumption	551,546.1	606,391.6	722,400.0	858,428.1	1,124,225.4	1,354,216.0	1.2
Net shipments ^j	174,388.1	187,795.0	268,013.4	293,050.1	333,273.6	384,063.8	0.7

Note: Production and consumption estimates are for areas in the ORB defined as origins and destinations of waterborne movements. The definition of areas varies by group.

a. Includes coal only.

(Continued) --

Table 1. (Continued)

- b. Includes corn, wheat and soybeans only. Corn is corn for grain. Wheat is all wheat. Soybeans are soybeans for beans.
- c. Includes manganese, liquid sulfur, rock salt, zinc ore and alumina.
- d. Includes lumber products, pulpwood logs and paper products.
- e. Includes lubricating oils and greases, napthas and asphalt.
- f. Includes lime and Portland cement.
- g. Includes the primary metal of aluminum, copper, lead, zinc, nickel, titanium, magnesium, tin, antimony, beryllium, chromium, manganese and cadmium and primary products of aluminum, copper and molybdenum.
- h. Includes fabricated metal products, machinery products, electrical machinery products, and ships and boats.
- i. Includes petroleum and coal products, nec.; slags; and waterway improvement and government materials.
- j. Total production minus total consumption.
- k. Less than + 0.01 Percent growth.

Source: Robert R. Nathan Associates, Inc.

Table 2. Ohio River System: Total Waterborne Commerce by Commodity Group,
Estimated 1976 and Projected 1980-2040, Selected Years
(Thousands of tons unless otherwise specified)

	Estimated 1976	Projected			Average annual percentage change	
		1980	1990	2000	2020	2040
Total: All groups	200,770.5	222,160.5	297,291.4	334,307.5	390,772.1	438,742.3
Group I: Coal and coke	116,532.9	130,390.6	183,495.7	204,160.8	228,100.2	253,656.9
Group II: Petroleum fuels	20,943.4	21,166.2	27,179.1	28,299.3	22,627.0	15,806.8
Group III: Crude petroleum	664.5	847.0	826.8	772.8	591.2	344.2
Group IV: Aggregates	25,152.3	27,554.0	30,140.2	31,763.7	37,032.2	40,276.0
Group V: Grains	5,582.0	4,153.5	4,996.6	6,043.0	7,275.0	8,637.4
Group VI: Chemicals and chemical fertilizers	11,364.0	12,396.0	16,533.7	22,419.6	37,564.8	49,195.3
Group VII: Ores and minerals	4,451.0	5,413.1	8,490.6	11,814.7	20,198.1	23,405.2
Group VIII: Iron ore, steel and iron	5,061.9	6,361.9	7,664.7	9,735.9	14,324.0	18,123.9
Group IX: Food and feed products, nec.	1,267.4	1,584.9	1,758.9	2,055.9	2,875.1	3,399.1
Group X: Wood and paper products	566.6	556.2	739.8	885.6	1,191.1	1,432.3
Group XI: Petroleum products, nec.	2,793.3	3,530.4	5,601.1	6,062.7	5,058.4	3,518.8
Group XII: Rubber, plastic, nonmetallic mineral products, nec.	1,471.3	2,573.0	3,980.5	4,598.7	6,031.9	7,020.1
Group XIII: Nonferrous metals and alloys, nec.	246.9	308.6	468.2	633.1	1,138.7	1,567.8
Group XIV: Manufactured products, nec.	351.6	508.7	701.8	970.1	1,665.8	2,216.3
Group XV: Others, nec.	4,319.4	4,811.4	4,713.7	4,801.1	5,038.6	5,142.7

Source: Robert R. Nathan Associates, Inc.

This rate of increase will decline during the period 2000-2040 when an average annual increase of only 0.7 percent is expected.

Traffic in ores and minerals is projected to have the highest rate of future change, closely followed by nonferrous metals and alloys and manufactured products.

While waterborne movements of most commodity groups are projected to increase during the study period, movements of petroleum-related groups are projected to decline, as are the production and consumption of these groups.

Total inbound waterborne shipments in the ORS are projected to increase at an average annual rate of 3.1 percent through the year 2000, and at an average annual rate of 1.8 percent between 2000 and 2040 (Table 3). A significant portion of this increase will result from increases in inbound shipments of coal (although most coal shipments will continue to be local).

Total outbound waterborne shipments on the ORS are projected to increase at an average annual rate of 2.3 percent between 1976 and 2000, and then to remain at a fairly stable level. The levels of outbound shipments between 2000 and 2040 in three groups (coal and coke, petroleum fuels, and other petroleum products) are expected to decrease, but most of these decreases will be offset by increases in other groups.

Local waterborne shipments within the ORS are expected to increase from 144.5 million tons in 1976 to 271.1 million tons in 2040. Most of this increase will be in local coal traffic, which is projected to increase by 92 million tons during the period.

E. Commodity Projections

Coal and Coke. Consumption of coal during the next 60 years is forecast to grow at a much slower rate than in the past, reaching a level of 606.6 million tons annually in 2040. The growth in consumption will occur as a result of increased consumption of coal by electric utilities. Metallurgical coal consumption is expected to decline through the next 20 years and to increase after the year 2000.

Production of coal is projected to increase at an average rate of 1.5 percent annually between 1976 and 2040. This accelerated production rate is a response to the increased demand for coal.

Table 3. Ohio River System: Waterborne Commerce, Total Inbound, Outbound and Local, Estimated 1976 and Projected 1980-2040, Selected Years
(thousands of tons unless otherwise specified)

	Projected				Average annual percentage change			
	1976	1980	1990	2000	2040	1976-2000	2000-2040	
Total	200,770.5	222,160.5	297,291.4	334,307.5	390,772.1	438,742.8	2.2	0.7
Inbound	29,439.5	29,722.2	45,770.5	61,239.4	93,591.7	122,576.4	3.1	1.8
Outbound	26,854.0	26,765.2	40,445.8	46,120.8	43,272.8	45,108.9	2.3	(0.1)
Local	144,477.0	165,673.4	211,075.2	226,947.3	253,907.6	271,057.5	1.9	0.5

Source: Robert R. Nathan Associates, Inc.

The percentage distribution of shipments by mode is not expected to shift markedly in the future: rail is expected to remain the dominant mode for shipping coal and coke; water is expected to be the second most important mode. Between 1976 and 2000, waterway flows are projected to increase at an average annual rate of 3.3 percent. The growth rate of waterway coal shipments is expected to decrease slightly in the following decades as alternative sources of energy are developed, and as pipeline transmission of liquefied or gasified coal replaces some waterway transport.

During the projection period, inbound shipments of coal are expected to increase rapidly as western coal begins to move into the area. However, most of this increase probably will not begin until the mid-1980s. Outbound waterborne movements of coal are expected to fluctuate while local movements are projected to increase slightly.

Petroleum Fuels. Future demand for petroleum fuels will be affected by supplies of crude oil and by energy conservation measures. The consumption of petroleum is projected to follow past trends and increase rapidly until 1990 and then decline in absolute amounts. Production was projected to grow at a rate of 3.17 percent per year from 1976 to 1980 and to decline thereafter at accelerating rates as a result of limited domestic crude oil production and higher import prices.

Gross waterborne shipments of petroleum are projected to increase from 20.9 million tons in 1976 to 28.3 million tons in 2000 and then to decline to 15.8 million tons by 2040. Most of this decline is expected to occur as a result of a drop in local shipments.

Crude Petroleum. Gross waterborne shipments of crude petroleum in the ORS declined from nearly 8 million tons in 1971 to only 0.7 million tons in 1976. The decline was partly due to lower crude oil production but primarily because of the development of an extensive pipeline system for local deliveries; pipelines have virtually replaced barge transport of crude oil for local shipments within the region.

All waterborne shipments of crude petroleum in the ORS are expected to be inbound. These shipments are projected to steadily decrease after 1980.

Aggregates. Because of the accessibility of production and consumption centers to water transportation, a much greater share

of aggregates shipments is waterborne in the ORB than in the Nation as a whole. In 1976, more than 16 percent of the area's output was shipped by water, compared to 6.5 percent nationally. A large part of aggregates production in the area is produced by dredging, and this material invariably moves by barge.

Gross waterborne shipments of aggregates are projected to rise from 25 million tons in 1976 to 31 million tons in 2000 and to 40 million tons in 2040. Local movements will continue to account for the bulk of waterborne shipments.

Grains. Although grains represented only 3 percent of total waterborne commerce in the ORS in 1976, they are one of the fastest growing waterborne commodity movements, flowing to and/or from almost every major PE in the inland waterway system. Grains also provide one of the higher-value and longer-haul movements in the ORS.

Between 1976 and 1980, waterway flows were projected to decrease, dropping from a 1976 level of 5.6 million tons to 4.2 million tons. This decline in production is a function of expected decreases in corn acreage, which yields almost three times as much grain per harvested acre as soybeans and wheat. To some extent, increases in soybean production offset the decline in corn. After 1980, waterway movements are expected to increase steadily to 6.0 million tons by 2000 and to 8.6 million tons by 2040. The majority of these shipments will be outbound.

Chemicals. Consumption of chemicals is projected to increase 3.2 percent annually through the year 2000 and at 2.1 percent from 2000 to 2040. Most of this increase will be in industrial chemical use. Agricultural chemical use will increase relatively little, primarily because of an expected shift away from corn production to soybeans. Production of industrial and agricultural chemicals in the area is projected to increase at a slightly faster rate than consumption.

Gross waterborne shipments of chemicals are projected to increase from 11.4 million tons in 1976 to 22.4 million tons in 2000 and to 49.2 million tons in 2040.

Ores and Minerals. Consumption of ores and minerals is projected to increase at an average annual rate of 4.4 percent from 1976 to 2000 and at a rate of 2.2 percent from 2000 to 2040. Most of the growth will result from increased demand for alumina due to a shift toward lighter materials in automobiles, increased use of

aluminum in housing and construction, and aluminum's relative cost advantage. Projections of consumption growth for other ores and minerals are somewhat lower.

The only major commodity in this group both produced and shipped in the ORB is zinc, the production of zinc is expected to grow 3.3 percent annually from 1976 to 2000 and 2.6 percent annually from 2000 to 2040. This is the same rate projected for national zinc production. Total inbound waterborne shipments of all ores and minerals are projected to rise to 10.5 million tons in 2000 and to 25.1 million tons in 2040. Outbound and local shipments will remain only a small part of total waterborne shipments.

Iron Ore, Steel, and Iron. The Ohio River Basin contains several of the major steel producing districts in the United States, accounting for approximately 30 percent of national steel production in 1976. The primary producing areas in the ORB are Pittsburgh, Youngstown, Cincinnati, and Huntington. The process used predominantly in these areas is the basic oxygen furnace, but a large number of older and less efficient open-hearth furnaces remain in operation. It is expected that steel plants operating in the ORB will be maintained and upgraded.

Gross waterborne shipments of iron ore, steel, and iron in the ORS are expected to increase at an average annual rate of 2.6 percent between 1976 and 2000 and 1.7 percent from 2000 to 2040.

Food and Feed Products. A steady increase in total food and feed products production is expected. This will narrow the gap that exists between consumption and production. Waterborne food and feed products are expected to remain a very small portion of total ORS traffic.

Wood and Paper Products. The consumption of wood and paper products in the ORB is projected to grow rapidly -- at an average annual rate of 4 percent through 1990. Production also will increase quickly, although at a slower rate than consumption.

Gross waterborne shipments of these commodities are projected to increase from 564 thousand tons in 1976 to 1.4 million tons in 2040. Local shipments will continue to dominate, although the most rapid growth, initially, will be in outbound movements.

Petroleum Products, Nec. Both consumption and production are projected to increase in the near term. However, they are projected to decline in the long run because of the shortage of crude

oil. For the entire period 1976 to 2040, a slight increase is projected. Production is expected to rise from 1.0 million tons in 1976 to 2.1 million tons in 2000 and then fall to 0.9 million tons in 2040. Gross waterborne traffic is projected to increase from 2.8 million tons in 1976 to 6.0 million tons in 2000. In the following decades, because of the effects of declining crude oil supplies, gross waterborne traffic is projected to decrease to 3.5 million tons by 2040.

Rubber, Plastic, and Nonmetallic Mineral Products, Nec. Both consumption and production of cement and lime (the major waterborne commodities of this group) are projected to increase in the next decades. Consumption is expected to rise at an average annual rate of 4.1 percent through 2000 and then at 0.9 percent annually. Production is expected to increase at slightly lower rates.

Trucks will continue to move the largest portion of shipments. However, gross waterborne shipments are projected to increase 4.9 percent per year from 1976 to 2000 and at 1.1 percent from 2000 to 2040, reaching 7.0 million tons in 2040.

Nonferrous Metals and Alloys, Nec. Consumption of nonferrous metals and alloys is expected to grow at average rates of 3.8 percent per year from 1976 to 2000 and 2.0 percent between 2000 and 2040. This growth is in line with projected U.S. consumption levels.

Production is expected to increase from 2.8 million tons in 1976 to 25.2 million tons in 2040. Production of aluminum, the major commodity in the group, is expected to continue its rapid growth.

Gross waterborne traffic is expected to increase from 0.2 million tons in 1976 to 1.6 million tons in 2040. Inbound waterborne shipments are expected to constitute the major component of gross shipments.

Manufactured Products, Nec. Waterborne shipments of this group were small throughout the historical study period and accounted for only 0.2 percent of total ORS waterborne traffic in 1976. Waterborne traffic of manufactured products will remain a small portion of total ORS shipments, totaling only 2.2 million tons in 2040, which will equal only 0.5 percent of all ORS traffic.

Other, Nec. This group consists of a large number of commodities which are generally insignificant in terms of their waterborne movements. These commodities have few common consumption, production, or transportation characteristics.

The gross waterborne movements of others, nec., are projected to increase from 4.3 million tons in 1976 to 5.1 million tons in 2040. Most of this increase is attributable to the inbound shipments of miscellaneous petroleum products.